Diet and spatial ecology of yellow baboons (*Papio cynocephalus*) in a human-dominated environment in Diani, Kenya

Internship report

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Diet and spatial ecology of yellow baboons (*Papio cynocephalus*) in a human-dominated environment in Diani, Kenya

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Abstract

In areas with a continuous expansion of human settlements, baboons can become serious pests when raiding crops, feeding at garbage piles or stealing food out of kitchens and hotel rooms. As part of the pest management programme of Colobus Conservation in the coastal tourist town Diani in Kenya, the five yellow baboon troops (*Papio cynocephalus*) were studied to determine their activity budget, quantify the diet composition and identify spatial patterns of baboon activity. We were especially interested in the types of provisioned food that the baboons feed on and determining the home ranges with areas of frequent baboon presence. Data was collected using instantaneous focal sampling and recording GPS position of the troops in regular intervals. The results revealed that the troops in Diani spent an average of 40.24 % of the daytime feeding, 25.82 % resting, 21.75 % moving, 8.92 % socializing and 3.08 % other, which was similar to the activity budgets of wild feeding baboons. Although there were significant differences between the troops, they spent more time feeding than provisioned groups in other regions. Fruits made up the largest proportion of the diet (58.68 %) followed by provisioned food (15.49 %), which differed significantly among the troops. The amount of human food in the diet was dependent on troop size as smaller troops relied more on provisioned food and used a variety of human food sources. The larger troops were mostly feeding on garbage. There were 20 hotspots with a high density of baboon activity and those were either close to artificial feeding sites (average distance of 30.52 m) or around sleeping sites (35.23 m). Five hotspot areas in immediate vicinity to highly frequented artificial feeding sites were identified as priorities for conflict mitigation activities, including a small-scale farm, a hotel kitchen and several garbage areas. These results emphasised the importance of implementing management strategies to deal with conflicts between humans and baboons.

Key words Activity budget · Artificial feeding sites · Hotspot analysis · Provisioned food · Pest management

Introduction

The continued increase of the human population and the expansion of agricultural land can lead to severe ecological changes in areas inhabited by non-human primates. Primate species that are able to adapt to those changing conditions can come into conflict with humans due to their intelligence, social cooperation and behavioural as well as dietary adjustability (Else 1991). Especially primates from the genera *Macaca*, *Cercopithecus* and *Papio* are known to raid agricultural crops, homes and gardens, feed from garbage piles, but also guest rooms and dining halls in tourist lodges (Campbell-Smith et al. 2010, Hill 2000, Lee et al. 1986). Primates take advantage of human food sources because they are high in carbohydrates as well as calories and lower in fibres when compared to natural foods (Strum 2010). Furthermore, the handling time is shorter and sites with human food are highly concentrated and predictable. When the acquisition of human foods by primates causes financial losses for people, those species are often considered a pest and serious human-wildlife conflicts can emerge (Hill and Wallace 2012). These conflicts can severely reduce the acceptances of wildlife and especially undermine conservation efforts of the pest primate or other primates inhabiting the area (Campbell-Smith et al. 2010).

Baboons (*Papio)* can adapt well to human modified environments because they digest human food and are opportunistic as well as omnivorous feeders. Baboons have been reported as pests throughout their range where they cause considerable damage to crops and properties, raid garbage areas and also harass humans directly for food (Hill 2000, Kaplan et al. 2011, Yihune et al. 2009). In Uganda Hill (2000) found that especially baboons are perceived as a threat to people's livelihoods and that the direct killing is seen as a preferred control strategy. In order to increase the acceptance of wildlife conservation under such circumstances, a thorough understanding of the conflict is necessary (Naughton-Treves 1998).

The strong growth in the tourism sector in Kenya in the last decades led to an expansion in developed areas and an increase of the human population in coastal communities. In Diani, at the southern coast, this led to the destruction of forests, a growth in build-up areas as well as infrastructure and an increase of human food waste, especially from hotels. There are five baboon troops of the species *P. cynocephalus* living in the area. All troops have daily contact with humans and use artificial feeding sites like garbage piles, hotel kitchens or small crop farms to supplement their diet. This so called provisioned food includes fruits and vegetables, but also cooked and processed food. This causes conflicts between humans and baboons, which are reflected in aggression towards the animals but also baboons being aggressive towards humans. Residents in the area frequently articulate distress about baboons taking food directly from people or from their kitchens as well as that the raiding of crops leads to financial losses. Baboons are chased away from properties by throwing stones or using dogs. At the same time tourists like watching baboons reinforced by the expectation of seeing big mammals when visiting Kenya.

Recently there have been studies on chacma baboons (*P. ursinus*) in a human-dominated environment in South Africa where Hoffman and O'Riain (2011) found that the baboons spent significantly more time in areas modified by humans such as plantations and vineyards where they were feeding on exotic plants. But the troops also took advantage of human foods from garbage areas and were raiding cars, houses and gardens (Kaplan et al. 2011). Baboons feeding on human food show increased growth rates (Strum 2010) and use a larger proportion of their time for resting and social interaction (Altmann and Muruthi 1988). Furthermore, females mature earlier and the survival rate of infants is higher (Altmann and Alberts 2003).

The most extensive study on yellow baboons in Kenya has been conducted for several decades in Amboseli where one of the troops used human food from the garbage area of a tourist lodge, which made up almost 40% of the diet. This troop differed from the natural feeding groups by travelling less per day and having a smaller home range (Bronikowski and Altmann 1996). However, in Amboseli the baboons live in a semi-arid habitat with grassland and groups of acacia trees where their natural diet mainly consists of grasses, tubers and different parts of the acacia trees (Altmann and Altmann 1970).

In contrast, in Diani the conditions are different with a rather tropical climate and consequently very different vegetation. This is the first study on this baboon species in an environment that has been dramatically altered by humans and where only a few patches of natural forest are left. This habitat offers baboons access to high energy human foods, an environment without natural predators but also risks such as dogs and a highly frequented street. Baboons in Diani have been using human food sources for decades as an early study on their crop-raiding behaviour suggests (Maples et al. 1976). At that time there were fewer hotels in the area surrounded by small-scale farms. Maples et al. (1976) described that the baboon troops were raiding the farms regularly but that crops made up only a minor proportion of their diet.

For this study we were interested in determining the activity budget of the baboons and what they feed on in a habitat dominated by human influences, as the diet composition of baboons in this kind of environment has not been studied before. We wanted to quantify the amount as well as the type of provisioned food in the diet. As all troops have been observed feeding on human food we expected them to spend less time feeding and more time resting than completely wild feeding troops (Altmann and Muruthi 1988). We also predicted that human food makes up a larger proportion of the diet of small troops compared to the larger troops as it is easier for smaller troops to remain undetected when raiding provisioned food sources (Else 1991).

Furthermore, the aim was to determine the home range of each baboon troop, the daily travel distance and to identify areas of high baboon activity. We expected larger groups to have a larger home range and travel longer distances (Dunbar 1992). The results were compared to previous studies on baboons, especially to groups with access to human-derived foods, and relationships between feeding behaviour and home range use are examined. Finally, hotspots of baboon activity and artificial feeding sites in close proximity to those areas were identified as priorities for the implementation of pest management activities to reduce the spatial overlap with humans.

Methods and Materials

Study site

The study was conducted in Diani, a small coastal town in Kwale district, 40 km south of Mombasa, Kenya (Fig. 1). The study area lies between latitudes 4°16' and 4°21' S and longitudes 39°33' and 39°36' E. The Kenyan coast is characterised by a mosaic of coastal forests which have been developed and degraded to different degrees and are interspaced with farms as well as built up areas (Hawthorne 1993). These forests were recognized as important biodiversity hotspots with a high number of endemic species being concentrated in small areas (Myers et al. 2000).

Diani is dominated by tourist development with large hotel complexes and residential areas lining up along the coast. There are also abandoned hotel grounds, a golf course and one main road that divides the study area from north to south. Those build up areas are interspaced with forest patches, most of them strongly degraded.

The vegetation in Diani forest is dominated by the so-called coral rag forest, which is a scrub forest growing on sedimentary rocks derived from recent corals. In those forests the canopy reaches

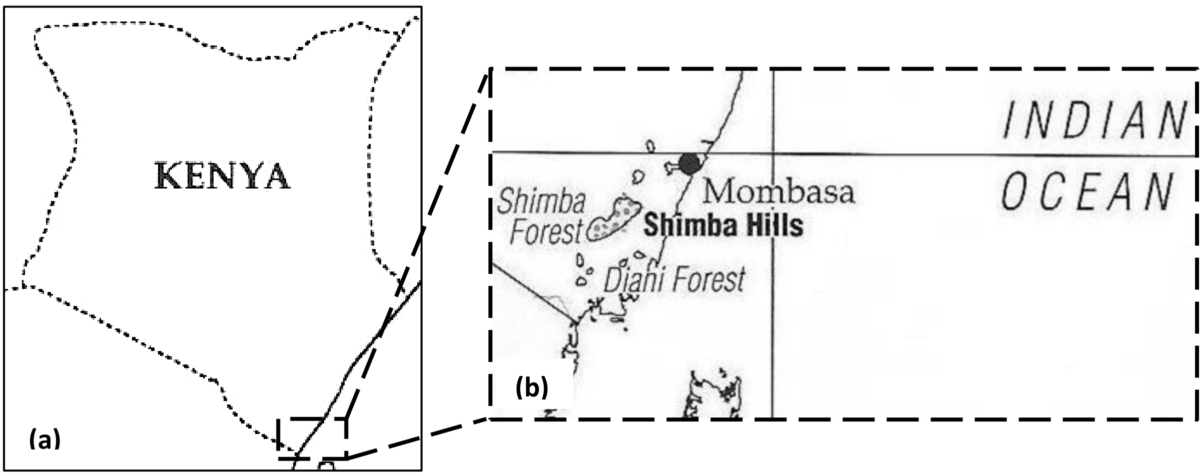

Figure 1. Map showing (a) the outline of Kenya. Source: Wasser and Lovett 1993 and (b) the location of Diani forest at the southern coast of Kenya between Mombasa and the Tanzanian border. Source: Rodgers et al. 1992.

a height of 6 - 10 m (Clarke and Robertson 2000) and herbs are usually absent. Furthermore, there are a number of Kayas, which are remnant patches of lowland forest that once covered the coastal belt of southern Kenya (Rodgers et al. 1992). Those forest areas have a canopy height of 25 – 35 m (Clarke and Robertson 2000) and are characterized by the presence of the tree species *Antiaris toxicaris*.

The climate is tropical and temperatures remain high during the rainy season. The average temperature in Mombasa is 26.8°C and average annual rainfall ranges between 900 and 1400 mm (Clarke 2000). However, due to seasonality rainfall varies markedly depending on the time of year. In the Kenyan coastal belt between 50 – 70 % of the rain falls during the three wettest months in the so-called long rains (Clarke 2000). The present study was conducted in the course of the short rains, which see markedly less rain than the long rains season. Day length was approximately 12 hours.

Study Population

There were five baboon troops living in the Diani area (Fig 2). According to a census in October 2012 the average group size was 29.6 ± 10.19 individuals. All troops were accustomed to the presence of humans so that they were habituated to behavioural observations from a distance of 10 m. The baboon troops were named A1, A2, B1, B2 and C according to classification used in past censuses.

Data collection

Data was collected from the beginning of September until mid December with troops being followed on a rotational basis. The method of instantaneous (point) focal sampling (Altmann 1974) was used with each individual being followed for 20 minutes. The behaviour of the focal animal was recorded every minute according to 21 categories which included for instance feeding, foraging, locomotion, resting and grooming (data sheet in Appendix II). When an individual was recorded feeding, the food type and, if applicable, the plant species was recorded. Infants were not included as focal subjects. The focal individual was selected randomly which ensured that easily visible or more dominant individuals were not oversampled.

The data was collected by the author and four field assistants (from Colobus Conservation, Diani, Kenya) whereby only one field assistant was with the author in the field for data collection at any time. Data was typically collected according to the following schedule: the troop was located during midday and then followed to its sleeping site, followed for the full day on the next day and from the sleeping site until midday on the consecutive day. The data set included 382.4 hours of observation with a mean of 4588.8 ± 150.34 minutes of observation for each group. Every group was followed for five full days from 6 am until 6 pm and eight or nine times for half a day.

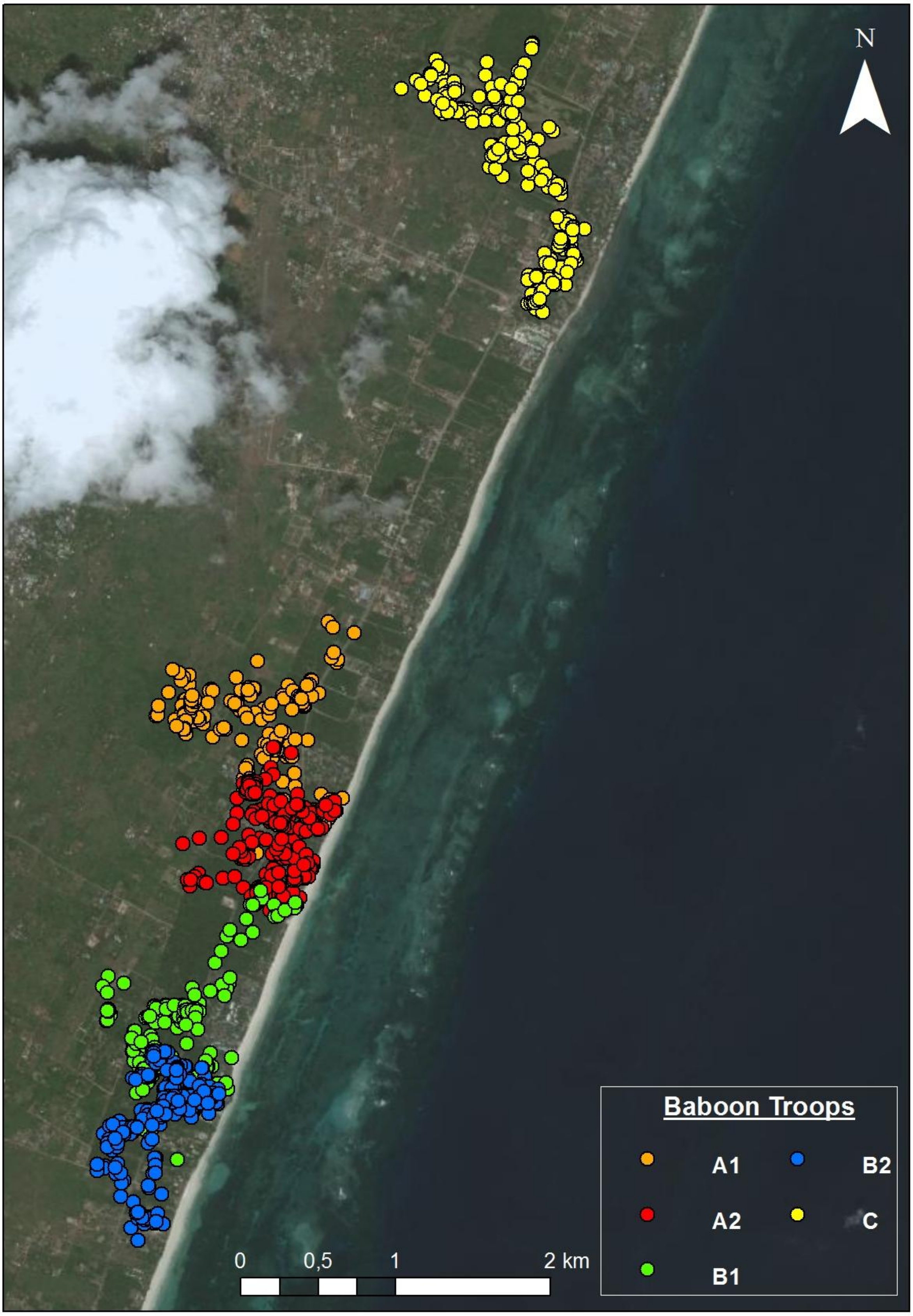

Figure 2. Aerial photo (Microsoft Corporation 2010) of the study area in Diani, Kenya, showing the GPS points recorded for the five yellow baboon troops (*Papio cynocephalus)*, visualising the relative spread of the troops. The home ranges of the four southern troops overlap considerably. The photo also reveals that the remaining forest patches along the coast are strongly fragmented by roads and private properties.

At the beginning of every focal sample the GPS position of the individual was recorded using a Garmin eTRex Summit handheld GPS device. An average of 262.2 ± 9.47 GPS points was recorded for each group. Furthermore, the GPS positions of sleeping sites and artificial feeding sites were recorded. Additional information on the artificial feeding sites was documented including whether the baboons coordinated their visit to the feeding site with new food arriving or whether they disregarded natural food sources close to artificial feeding sites.

Data analysis

The behavioural data was combined into five categories, which correspond to categories in other publications (Bronikowski and Altmann 1996, Dunbar 1992, Hoffman and O'Riain 2011) in order to allow for comparisons. The category *feeding* included active searching, handling and consumption of food (Dunbar 1992). *Moving* meant any form of directed movement and *resting* was defined as sitting or lying not doing anything else. *Socializing* described social interactions, especially grooming. Other behaviours such as self-grooming or drinking were combined in the category *other*. The food types were merged into the categories provisioned food, fruit, seed, leave, root, insect and other. The data was summarized by first calculating the relative frequency in percentage terms of each category for each baboon troop. Then means across the five troops were calculated with the standard deviation (mean ± SD). For the statistical analysis of the activity budgets and the diet composition a chi-square test was used to test for differences between the five baboon troops. Then a pairwise comparison of the troops was made using chi-square test with bonferroni-correction as a post-hoc test. To determine differences in the means of the daily path lengths a one-way ANOVA with Tukey post-hoc test was used. Relationships between variables were analysed using linear regression. Data analysis was done in R 2.15.2. (R Core Team 2012) with a p-value of less than 0.05 considered significant.

For the spatial analysis the GPS data points were imported into ArcGIS 10.0 (ESRI 2010). To calculate the home range size, a layer of grid cells was created with the size 150 x 150 m (0.023 km^2) in order to ensure that a troop was not spread through more than one cell at a time (Hoffmann and O'Riain 2011). The number of entered cells was multiplied with the cell area to derive the overall home range size. The density was calculated by dividing the home range by the troop size. The daily path length was analysed using the point to line tool in ArcGIS by connecting the consecutive GPS points for full day follows and then measuring the total length using the calculate geometry tool.

To identify areas with a high likelihood of human-baboon conflict a hotspot analysis was run in ArcGIS. The GPS points were integrated using a threshold of 20 m, which corresponds to the accuracy of the GPS device. For the hotspot analysis a fixed distance of 34 m was used which reflects the spatial autocorrelation measured with global Moran's I as this represents a distance where there are pronounced processes of spatial clustering (ESRI 2012). Hotspots were defined as significant with $p<0.05$. The distance from hotspots to artificial feeding sites and sleeping sites was measured using the point distance tool.

Results

Activity budget

The baboon troops spent an average of 40.24 ± 5.59% of the daytime feeding, 25.82 ± 4.66% resting, 21.75 ± 2.05% moving, 8.92 ± 0.37% socializing and 3.08 ± 0.63% other (n=22 944). There were significant differences in the composition of activity budgets of the different troops (Fig. 3). It is especially noticeable that troop B2 spent significantly less time feeding (chi-square test: $p<0.001$, n=9268) and significantly more time resting than the other troops (chi-square test: $p<0.001$, n=5926). Group A1 spent significantly more time moving than the other troops (chi-square test: $p<0.001$, n=4995). Troops A2 and C spent the highest proportion feeding compared to the other troops. There were no significant differences in the relative frequency of socialising (chi-square test: $p=0.57$, n=2048).

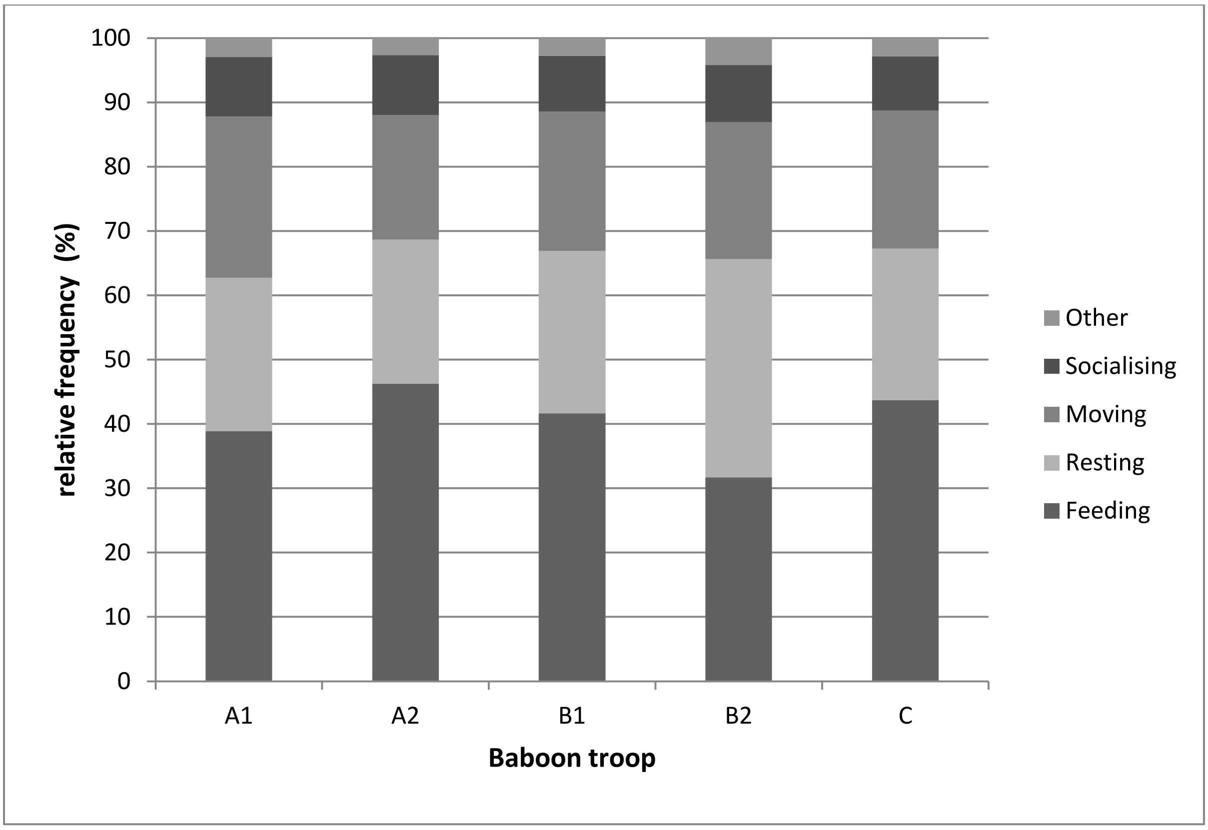

Figure 3. Activity budget of *Papio cynocephalus* in Diani, Kenya, showing the relative frequency (%) of each behavioural category for the five baboon troops. Differences between the groups were significant for the category feeding (Chi-square test: $p<0.001$, n=9268), moving (Chi-square test: $p<0.001$, n=4995) and resting (Chi-square test: $p<0.001$, n=5926).

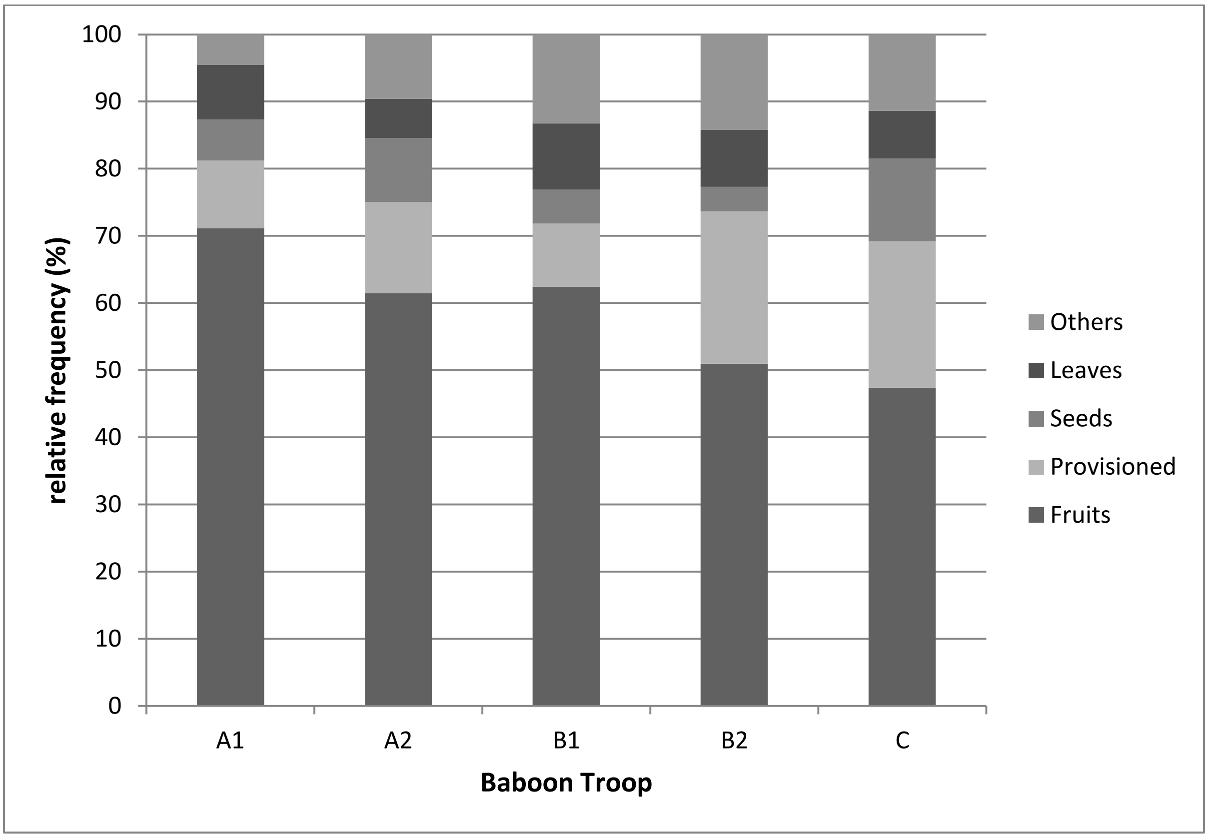

Figure 4. Relative frequency (%) of food types consumed by five groups of *Papio cynocephalus* in Diani, Kenya. The proportions in provisioned food were significantly different between the five troops (Chi-square test: $p<0.001$, $n=1209$).

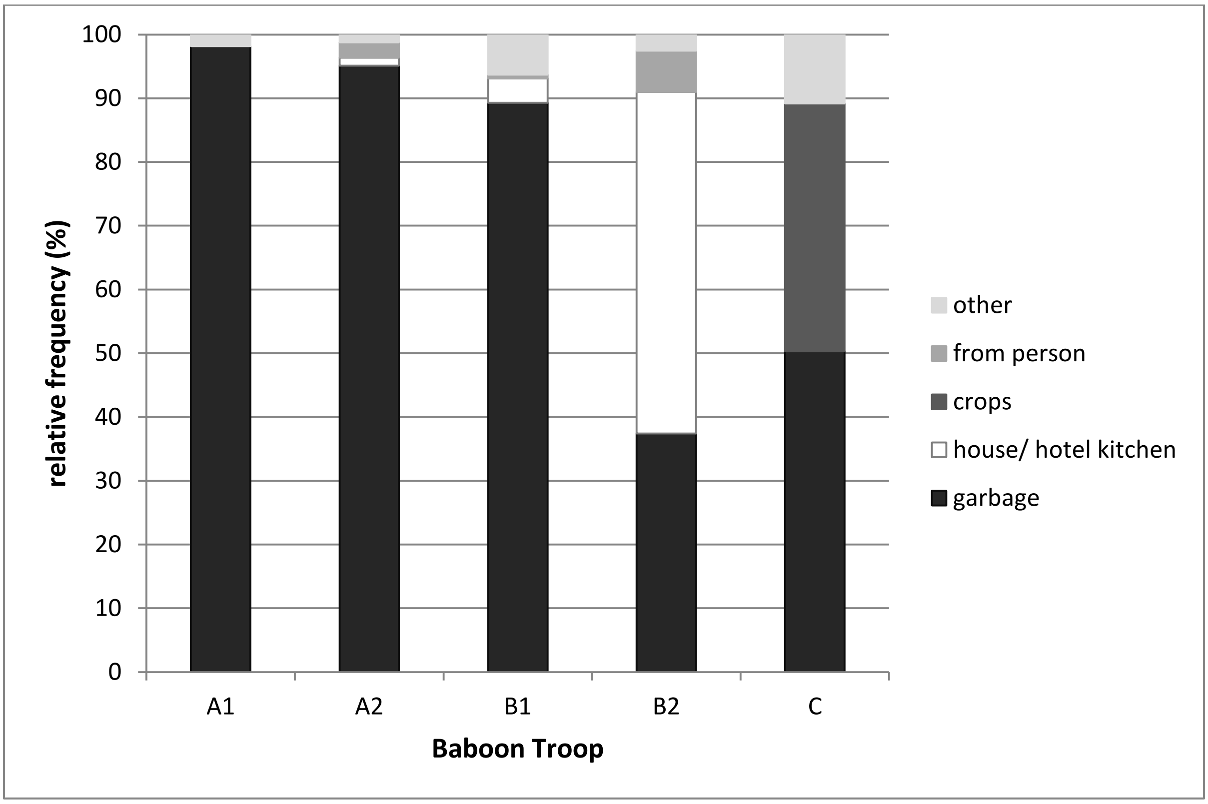

Figure 5. Relative frequency (%) of types of provisioned food consumed by five groups of *Papio cynocephalus* in Diani, Kenya with n=1209.

Diet

For all five baboon troops fruits accounted for the biggest proportion of consumed food types (58.68 ± 9.55%, n=8045). Provisioned food was the second largest proportion (15.49 ± 6.38%), but numbers varied significantly between the troops (chi-square test: $p<0.001$, n=1209). While troops A1 and B1 fed on provisioned food around 10% of the records, groups B2 and C have the biggest proportion of provisioned food with more than 20% (Fig. 4).There was a significant negative relationship between troop size and the proportion of provisioned food in the diet (linear regression: coefficient $\beta=-0.62$, $p=0.002$, adjusted $R^2=0.96$).

The analysis also revealed that the baboon troops used different types of provisioned food (Fig. 5). All troops relied heavily on garbage, which made up around 90% of the provisioned food for troops A1, A2 and B1. The other two troops, which were the ones with the highest proportion of provisioned food in their diet, also fed on other sources. Troop B2 fed mainly on food from houses and hotel kitchens while troop C raided crops.

The food type category "others" included different plant parts such as buds and roots, mushrooms, but also insects and single records of birds and a suni (*Neotragus moschatus*), a very small antelope. The majority of plant species consumed were indigenous species (86.29 ± 10.35%, n=6566) such as the baobab (*Adansonia digitata*), tamarind (*Tamarindus indica*) or *Ficus* species. Troop C fed on the largest proportion of exotic plants (30.75%, n=1251), especially on *Terminalia mentalis* and *Terminalia catappa*, which are both exotic almond species.

Home range

The analysis revealed that the home ranges of the troops ranged between 0.70 and 1.20 km^2 and that the baboon density was 29.28 ± 7.50 individuals/km^2 (Table 1). Daily path length ranged between 2.11 and 3.65 km (Table 1) and there were significant differences between some of the troops (ANOVA: A1 and A2, $p=0.002$; A1 and B2, $p=0.01$; A2 and C, $p=0.04$). A total of 20 sleeping sites were recorded with each troop using at least two different sleeping sites. Where the ranges of troop A1 and A2, overlapped one site was used by both troops for sleeping, but never at the same time. A total of 43 artificial feeding sites were documented, mostly garbage piles but also hotel restaurants, kitchens and two small farms. Several of those feeding sites were used by different troops especially where the home range of troop A1 and A2 as well as those of B1 and B2 overlapped. There was neither a significant relationship between troop size and home range (linear regression: coefficient $\beta=0.02$, $p=0.23$) nor between troop size and daily path length (linear regression: coefficient $\beta=0.01$, $p=0.79$).

The hotspot analysis identified 20 spots with a significant concentration of baboon activity. These hotspots can be combined to 13 areas of high baboon activity, as some of the spots are on the

Table 1. Home range, density and daily path length of baboon troops (*Papio cynocephalus*) in Diani, Kenya. The daily path length is the average with standard deviation for full day follows (n = 5).

Troop name	Troop size	Home range [km^2]	Density [baboons/km^2]	Daily path length [km]
A1	36	1.17	30.77	3.65 ± 0.61
A2	33	0.90	36.67	2.11 ± 0.49
B1	41	1.15	35.65	2.71 ± 0.74
B2	17	0.70	24.29	2.38 ± 0.28
C	21	1.10	19.09	3.17 ± 0.50

same property (Appendix I). Three of those hotspot areas were in a forest or on an abandoned property. However, the remaining hotspots were all located on built-up areas either within residential properties or on hotel grounds. The hotspots were in proximity to artificial feeding sites (30.52 ± 18.28 m, n=9) or close to sleeping sites (35.23 ± 21.43 m, n=10). One hotspot was located at a group of *Tamarindus indica* trees, which was one of the most preferred plant species in this study (see above). Prioritising conflict areas, it was found that Baobab Hotel kitchen (144 counts), Papaya plantation (142) and the garbage piles at the Christian Academy (129), Former Two Fishes staff quarter (117) and Baobab hotel (64) were the most frequented artificial feeding sites (Appendix I, n=1009).

Discussion

This study revealed significant differences in the activity budget and the composition of the diet for the five yellow baboon troops living in Diani. This is surprising considering that due to the close proximity the environmental conditions are constant for all troops. In comparison to other studies the composition of the activity budget is similar with feeding making up the largest proportion followed by resting and moving (Table 2). Contrary to our expectations the proportion of time spent feeding was higher than the record for the provisioned baboon troop at Amboseli (Lodge Group in Table 2). This could be explained with the fact that the proportion of provisioned food is with an average of 15.49% lower than the 38% reported for the provisioned troop at Amboseli (Altmann and Muruthi 1988). However, such comparisons have to be treated carefully as the troops in Diani were only studied for three months at the end of the rainy season. Consequently, variability between different seasons and years is not reflected in this data, which makes comparison to long-term studies ambiguous.

The data of this study also affirmed that groups with a higher proportion of human food in their diet spent less time feeding and more time resting as has been shown for group B2 (Altmann and Muruthi 1988). However, troop C, which had a similar proportion of provisioned food in their diet as troop B2, did not reflect this observation. This might be due to the fact that troop C used two sleeping sites which were on opposite ends of the home range and that they therefore had a longer daily travel distance than troop B2 (Table 1). However, this difference was not significant. Furthermore, it is striking that troop size is the one factor that explains the proportion of consumed provisioned food with smaller groups feeding more on human food. It was speculated that this is an adaptation to human induced costs as smaller troops are less likely to be discovered by humans (Else 1991). Forthman Quick (1986) found that the fission of a troop could be explained by the tendency of some group members to take advantage of human food, which also reinforces the tendency towards smaller groups when raiding provisioned food.

For all troops in Diani fruits made up the largest part of the diet, which reemphasises that the environmental conditions here differ crucially from those in Amboseli. The home range of the baboon troops in Diani were small compared to other studies (Table 3) which reflects the trend that provisioned baboon troops have a smaller home range (Strum 2010). Surprisingly, the comparison to other studies also revealed that the density of baboons is very high in Diani, which is an indication of the high quality of the habitat for baboons (Dunbar 1992).

Table 2. Comparison of activity budgets from different studies of *Papio cynocephalus* in Kenya and Tanzania.

Reference	Study area	Troop name	Troop size	Activity budget (%)			
				Feeding	Moving	Resting	Socialising
this study	Diani, Kenya	A1	36	38.84	25.04	23.91	9.26
this study	Diani, Kenya	A2	33	46.26	19.39	22.40	9.30
this study	Diani, Kenya	B1	41	41.66	21.61	25.25	8.70
this study	Diani, Kenya	B2	17	31.69	21.26	33.95	8.92
this study	Diani, Kenya	C	21	43.67	21.44	23.60	8.44
Bronikowski & Altmann 1996	Amboseli, Kenya	Alto's Group	64.9 ± 7.9	44.8 ± 9.2	25.1 ± 4.5	20.9 ± 4.9	9.3 ± 2.2
Bronikowski & Altmann 1996	Amboseli, Kenya	Hook's Group	53.4 ± 7.5	48.1 ± 6.1	27.0 ± 5.0	16.3 ± 3.7	8.6 ± 0.9
Bronikowski & Altmann 1996	Amboseli, Kenya	Lodge Group	48.17 ± 6.9	23.7 ± 1.6	19.2 ± 2.5	43.8 ± 4.0	13.3 ± 1.2
Dunbar 1992	Gombe, Tanzania		43	25.8	19.4	30.2	10.6
Dunbar 1992	Ruaha, Tanzania		72	47.4	24.2	16.7	4.5
Dunbar 1992	Mikumi, Tanzania		120	36.5	26.1	25	5.9

The hotspot analysis revealed different areas of high baboon activity, which were usually at sleeping sites, at fruit trees or artificial feeding sites and were especially concentrated in areas where the home ranges of troops overlapped. It could be speculated that the home ranges overlied in those areas because of the artificial feeding sites, but still it is difficult to ascertain in how far those artificial feeding sites influence the use of the home range. This is mainly due to methodological constraints. At several sites there are fruit trees close to artificial feeding sites and while some individuals fed on the provisioned food others fed on the fruits. To truly infer that the artificial feeding sites influence how the home range is used, one would have to sample all possible artificial feeding sites within and around the home range to conclude influences. This is almost impossible, as the human observer is unlikely to recognize all possible feeding sites. However, this analysis showed that artificial feeding sites are in average located 30.5 m from hotspots, which allows for inferences about their importance for the spatial distribution of baboon activity.

The troops fed on different types of provisioned food, so that they are in conflict with humans to different degrees. Animals feeding from garbage areas are generally less in competition with humans than the ones raiding crop fields or taking food from kitchens. The farmers at the papaya plantation tried to deter the baboons for instance by throwing glass bottles and were also armed with bow and arrow. This also shows that raiding provisioned food sources can entail benefits as well as costs for baboons. It has been demonstrated that provisioned females started reproducing at an earlier age and that interbirth intervals were shorter (Strum 2010). At the same time in Diani, the baboons are often chased away either by throwing stones at them or using dogs whereby baboons, especially the more vulnerable females and infants, can be injured. To circumvent this, baboons eat human foods very fast, fill their cheek pouches and take with them as much as they can carry to avoid human threats (Else 1991).

Table 3. Comparison of home range size and density between *Papio* groups in different study areas in Kenya. The * stresses that the density calculations for those studies where not mentioned in the publications but were calculated here for the purpose of comparison as the mean of the home range divided by the troop size.

Reference	Species	Troop name	Troop size	Home range [km^2]	Density [baboons/km^2]
this study	P. cynocephalus	A1 - C	17-41	0.7-1.2	19 - 37
Bronikowski & Altmann 1996	P. cynocephalus	Lodge Group	48.17 ± 6.9	4	12 *
Bronikowski & Altmann 1996	P. cynocephalus	Hook's Group	53.4 ± 7.5	40	1,3 *
Strum 2010	P. anubis	Raiders	28 ± 4.2	4.5 – 8.75 km^2	4.24 *
Strum 2010	P. anubis	Nonraiders	67.5 ± 2.5	13 - 21.5 km^2	3.9 *

There are different approaches to deal with baboons in human-dominated environments. These often include the trapping and removal of certain individuals or entire groups, which is usually a short-lived success as other troops move into the area (Lee et al. 1986). Kaplan (2011) used patches of provisioned food to attract chacma baboons away from urban areas, which only worked in combination with restricting access to human food sources. Still he argues against it being a long-term solution, as it may lead to unforeseen ecological changes and might entail other problems.

In an environment with tourists and hotels deterrent strategies include discouraging tourists from feeding primates (Lee et al. 1986) and enforcing an effective garbage management which might include regular burning and restricting the access of baboons to garbage areas by using fencing or well ventilated buildings. Some of these measurements have already been successfully enforced in Diani by the primate protection organisation Colobus Conservation (Andrea Donaldson, pers. comm.). In other regions, the trialling of different techniques to deter primates from small-scale farms demonstrated that systematic guarding and other inexpensive techniques such as warning systems with bells or repellents can effectively deter baboons (Hill and Wallace 2012). However, such measures have to be adapted to the specific raiding behaviour of the relevant group and should be implemented in close collaboration with farmers (Hill and Wallace 2012).

Considering the ranking of the most frequented artificial feeding sites in this study, priorities should be given to deter baboons from small-scale farms, working with the management of hotels to remove incentives for baboons to steal food from kitchens and initiate an improved garbage management across Diani. An effective pest management strategy is especially relevant in a human-dominated environment considering that provisioned baboon groups show a stronger population growth due to shorter interbirth intervals, faster growth and higher survival rate of infants (Altmann and Alberts 2003) which would ultimately lead to an aggravation of the primate pest problem.

In order to fully characterize the baboon troops in Diani, it would be necessary to study in how far diet and home range use change towards the end of the dry season. Studies on yellow baboons have shown that the seasonality in activity budget and feeding ecology is less dominant in provisioned groups compared to wild feedings ones (Bronikowski and Altmann 1996). However, towards the end of the data collection an expansion of the home range was already observed. In times of food resources being scarcer we would also expect an increase in competition over provisioned foods and therefore, an increase in hotspots of baboon activity in built-up areas with artificial feeding sites.

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Appendix I:

Maps illustrating the distribution of yellow baboon troops in Diani, Kenya, with hotspots of baboon activity.

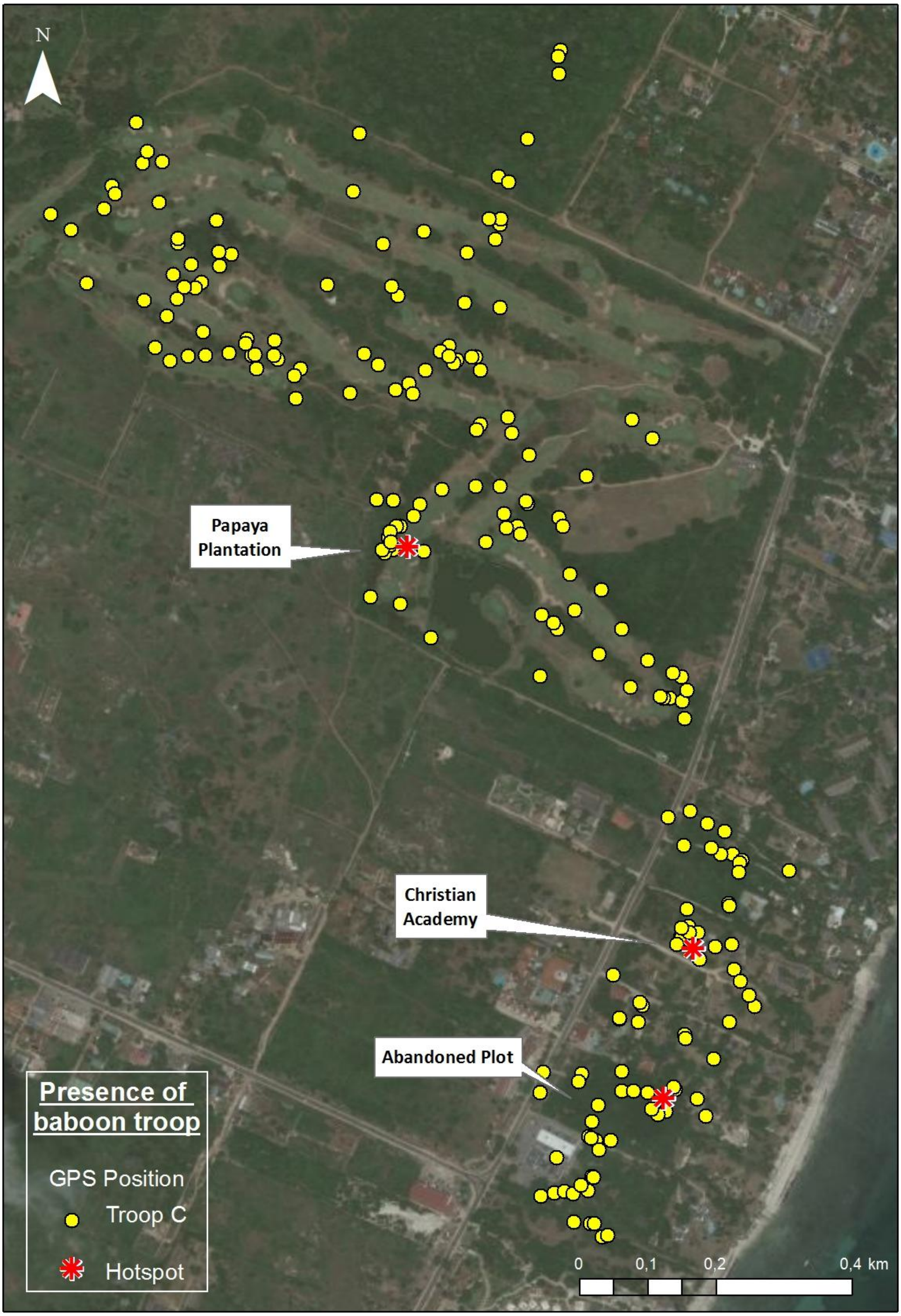

Figure 1: Map (Microsoft Corporation 2010) of the northern part of the study area depicting the recorded GPS positions for troop C with hotspots of baboon activity. The three areas with a hotspot are labelled. All hotspots were significant with p<0.05.

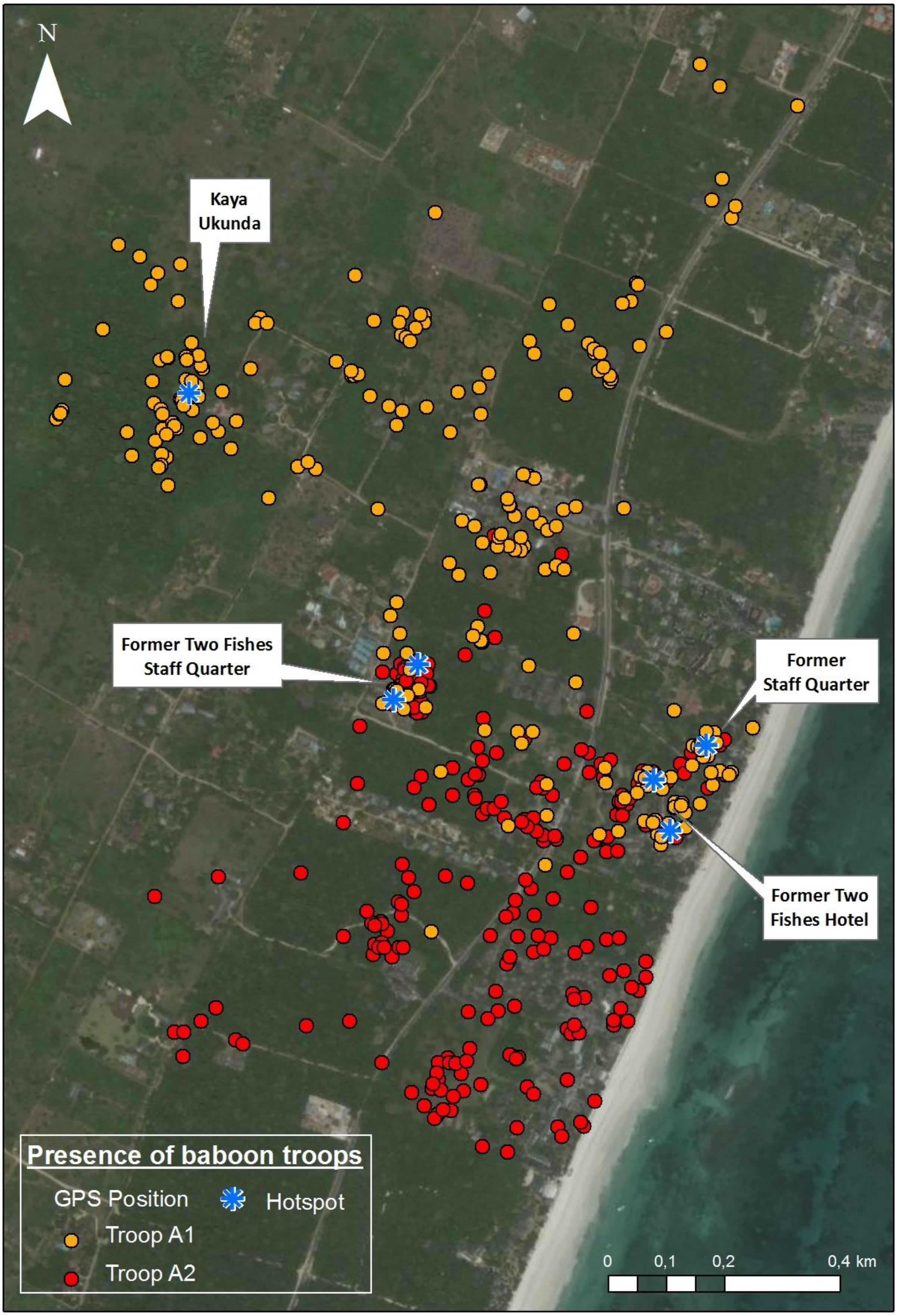

Figure 2: Map (Microsoft Corporation 2010) of the central part of the study area showing the recorded GPS positions for troops A1 and A2 with hotspots of baboon activity. The hotspots can be grouped into four areas as labelled on the map. All hotspots were significant with p<0.05.

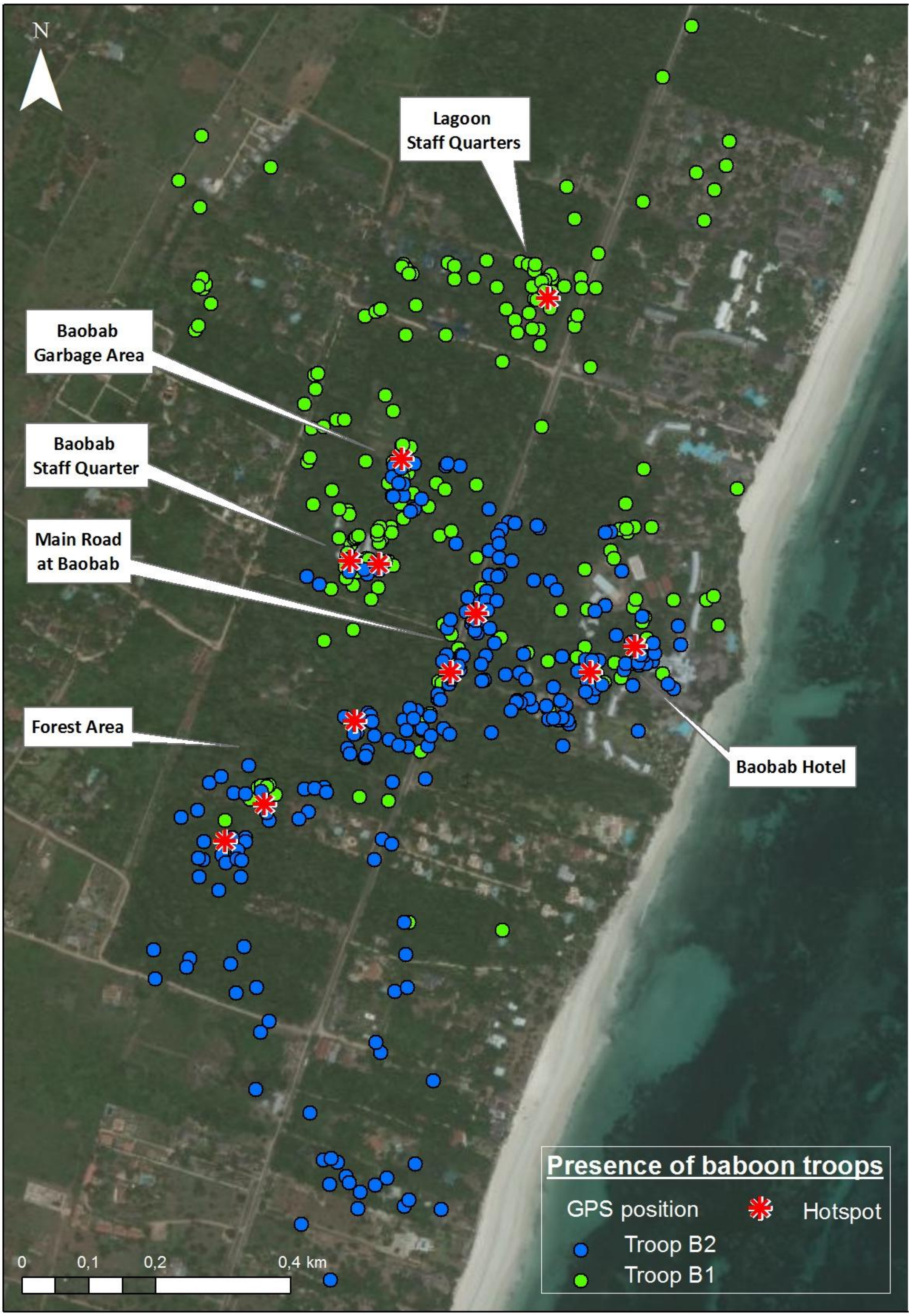

Figure 3: Map (Microsoft Corporation 2010) of the southern part of the study area depicting the recorded GPS positions for troop B1 and B2 with hotspots of baboon activity. The hotspots can be grouped into six areas as labelled on the map. All hotspots were significant with p<0.05.

Appendix II: Categories and data sheets used for data collection.

Table 1: Categories and codes for the recorded behaviour.

Code	Description of Behaviour
A+	Aggression (Actor)
A-	Aggression (Reactor)
C	Contact (individuals touching but not grooming)
FE	Feeding
FO	Foraging (active searching and handling of food)
G+	Grooming (being groomed)
G-	Grooming (grooming another primate)
L	Locomotion (any directed movement)
MA	Mating
MO	Mounting
N	Nursing (mother breast feeding)
O	Other
PL	Playing
PR+	Presenting (being presented to by another primate)
PR-	Presenting (presenting itself to another primate)
R	Resting
SC	Scratching
SG	Self grooming
SU	Suckling (juvenile feeding from mother)
V	Vigilant
Y	Yawn

Table 2. Categories and codes for the recorded food types.

Code	Food type
BU	Buds
FL	Flowers
FR	Fruits
G	Grass
I	Insects
M	Mushroom
ML	Mature leaves
O	Other
P	Pods
PF	Provisioned food
R	Roots
S	Seeds
TB	Tree bark
UK	Unknown
YL	Young leaves

Table 3. Categories and codes for the recorded type of provisioned food.

Code	Type of provisioned food
1	Garbage pile
2	Waste/ rubbish bin
3	Taken from hotel room
4	Taken from guest table
5	Taken from buffet table
6	Taken from guest bag
7	Taken from house kitchen
8	Taken from house dining area
9	Taken from person's hand
10	Offered by person
11	Crop raiding
12	Taken from hotel kitchen

Baboon Focal Study Data Sheet 1

Study Group: ____________________ *Observer:* ____________________ *Date:* ______________ *Focal Ref No:* ____________________

Research Period: Morning ☐1 Afternoon ☐2

Focal 1 Start Time	Individual I.D.						Sex:			Age:			Cycle stage (female only):								Notes
	Weather:						Focal Interval/minutes						G.P.S.:								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Behaviour																					
Association																					
Food Type																					
Plant Species																					
Position in Canopy																					
Focal 2 Start Time	Individual I.D.						Sex:			Age:			Cycle stage (female only):								Notes
	Weather:						Focal Interval/minutes						G.P.S.:								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Behaviour																					
Association																					
Food Type																					
Plant Species																					
Position in Canopy																					
Focal 3 Start Time	Individual I.D.						Sex:			Age:			Cycle stage (female only):								Notes
	Weather:						Focal Interval/minutes						G.P.S.:								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Behaviour																					
Association																					
Food Type																					
Plant Species																					
Position in Canopy																					
Focal 4 Start Time	Individual I.D.						Sex:			Age:			Cycle stage (female only):								Notes
	Weather:						Focal Interval/minutes						G.P.S.:								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Behaviour																					
Association																					
Food Type																					
Plant Species																					
Position in Canopy																					
Focal 5 Start Time	Individual I.D.						Sex:			Age:			Cycle stage (female only):								Notes
	Weather:						Focal Interval/minutes						G.P.S.:								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Behaviour																					
Association																					
Food Type																					
Plant Species																					
Position in Canopy																					

Figure 1. Data sheet for the collection of behavioural data.

GPS data for hotspots of baboon activity

Hotspot	Area description	GPS point	
		South	East
1	Forest area	-04.3396	039.5626
2	Forest area	-04.3391	039.5631
3	Forest area	-04.3380	039.5643
4	Main Road at Baobab	-04.3373	039.5656
5	Main Road at Baobab	-04.3365	039.5660
6	Baobab Hotel Kitchen	-04.3373	039.5675
7	Baobab Hotel Kitchen	-04.3369	039.5681
8	Baobab Staff Quarter	-04.3358	039.5643
9	Baobab Staff Quarter	-04.3359	039.5646
10	Baobab Garbage Area	-04.3344	039.5650
11	Lagoon Staff Quarter	-04.3323	039.5669
12	Former Two Fishes Hotel	-04.3213	039.5746
13	Former Two Fishes Hotel	-04.3205	039.5744
14	Former Staff Quarter	-04.3199	039.5752
15	Former Two Fishes Staff Quarter	-04.3193	039.5703
16	Former Two Fishes Staff Quarter	-04.3187	039.5706
17	Kaya Ukunda	-04.3144	039.5671
18	Empty Plot (next to Barclay's Centre)	-04.2894	039.5882
19	Christian Academy	-04.2874	039.5887
20	Papaya plantation (Golf course)	-04.2821	039.5849